Electron spectroscopy at the high-energy endpoint of electron-nucleus bremsstrahlung

P.-M. Hillenbrand[1,2], S. Hagmann[1,3], D. Banas[4], C. Brandau[1,5], K.-H. Blumenhagen[6], W. Chen[1], A. Gumberidze[5], D. Guo[7], E. DeFilippo[8], C. Kozhuharov[1], M. Lestinsky[1], Y.A. Litvinov[1], A. Müller[2], H. Rothard[9], S. Schippers[2], M. Schöffler[3], U. Spillmann[1], S. Trotsenko[1,6], N. Winckler[1], X. Yan[7], and Th. Stöhlker[1,6]

[1]GSI Darmstadt; [2]Universität Giessen; [3]Universität Frankfurt; [4]JKU, Kielce, Poland; [5]EMMI Darmstadt; [6]Helmholtz Institut Jena; [7]IMP, Lanzhou, China; [8]INFN, Catalania, Italy; [9]CIRIL-Ganil, Caen, France

In electron-nucleus bremsstrahlung an electron with kinetic energy E_0 scatters inelastically off an atomic nucleus and emits a photon of energy E_γ under energy conservation $E_0 = E_f + E_\gamma$:

$$e_0(E_0) + A \rightarrow e_f(E_f, \vartheta_f) + A + \gamma(E_\gamma, \vartheta_\gamma) \quad (1)$$

The coincident detection of scattered electron $e_f(E_f, \vartheta_f)$ and bremsstrahlung photon $\gamma(E_\gamma, \vartheta_\gamma)$ provides the most stringent tests for our understanding of the coupling between a matter field and an electromagnetic field.

Of particular theoretical interest is the case, when the entire kinetic energy of the incident electron is transferred to the photon; the theoretical description of the resulting high-energy endpoint of the electron-nucleus bremsstrahlung spectrum is closely related with photoionization PI and radiative electron capture REC. This process is not accessible in classical setups, where energetic electrons are scattered off high-Z target atoms at rest.

However, using a setup in inverse kinematics, namely highly charged heavy projectiles from the ESR, like U^{88+}, scattering off quasi-free electrons, enables us to perform coincidence measurements at the high-energy endpoint, as the scattered electron at rest in the moving frame appears in the $0°$-cusp in the laboratory frame. Here the electron can be understood alternatively as radiatively captured into the continuum of the projectile (RECC).

In order to measure triple differential cross-sections $d^3\sigma/dE_e/d\Omega_e/d\Omega_\gamma$ of the RECC process a beam of U^{88+} was injected into the ESR at 90MeV/u intersecting a supersonic N_2 gas target. Cusp-electrons emitted from the gas target into the forward direction ϑ_f=0° at velocities close to the projectile velocity where detected with the ESR electron spectrometer. The spectrometer consists of two $60°$-dipole magnets for momentum analysis and an iron-free quadrupol-triplett in between the dipols to enable telescopic imaging onto a position sensitve MCP-delayline-detector (cf. last annual report [1]). To measure the X-rays five standard Ge-detectors where used at angels $\vartheta_\gamma = +35°, +90°, +150°, -90°$, and $-145°$ around the interaction point. Particle detectors in the ESR dipole magnets where used to detect capture and ionization events.

Using this setup we were able to measure for the RECC process the electron energy distribution for five different photon emission angles, and accordingly the photon angular distribution of the electron-nucleus bremsstrahlung at the high-energy endpoint.

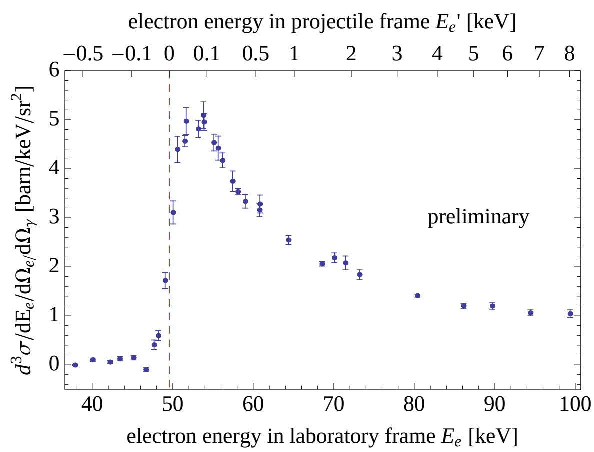

Figure 1: Electron energy distribution for forward emitted electrons in coincidence with a photon emitted at $\vartheta_\gamma = +90°$.

Fig. 1 shows examples of preliminary results for the electron energy distributions. The cross section is given differentially in electron energy dE_e, electron emission angle $d\Omega_e$ and the photon emission angle $d\Omega_\gamma$ while being integrated over the energy of the coincident photon energy E_γ. The distribution is peaked above the electron energy of $E_0 = 49.6keV$ corresponding to $E'_f = 0$ projectile frame energy. The strong asymmetry of the cusp shows that electrons are in the projectile frame predominately emitted into the forward direction. The spectra will be compared with state-of-the-art theories such as [2].

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References

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